

REPORT DOCUMENTATION PAGE

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

2 items enclosed = 216 + 213

④ Paper Rec'd After 30-day Deadline = { 22 days until Deadline }
FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

03 Sept 2002

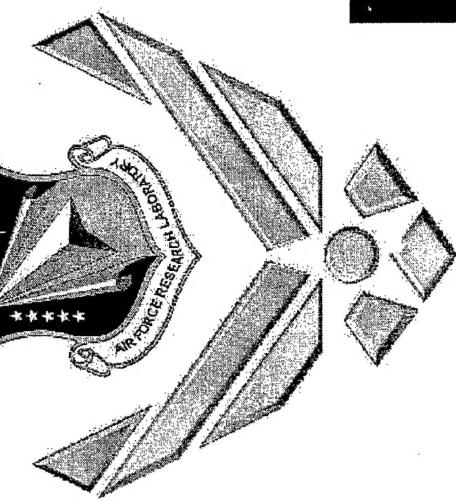
SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-213**
Shawn Phillips (PRSM), "AFRL POSS Applications Research" (viewgraphs)

POSS Nanotechnology Conference
(Huntington Beach, CA, 25-27 September 2002) (Deadline: 25 Sept 02) (Statement A)

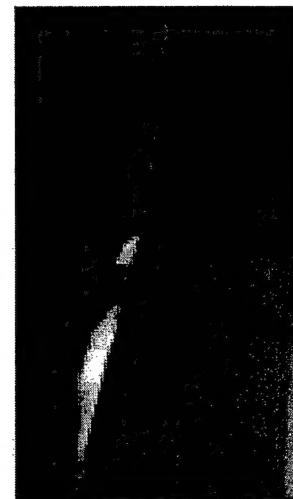
AFRL POSS[®]

Applications Research

Dr. Shawn Phillips



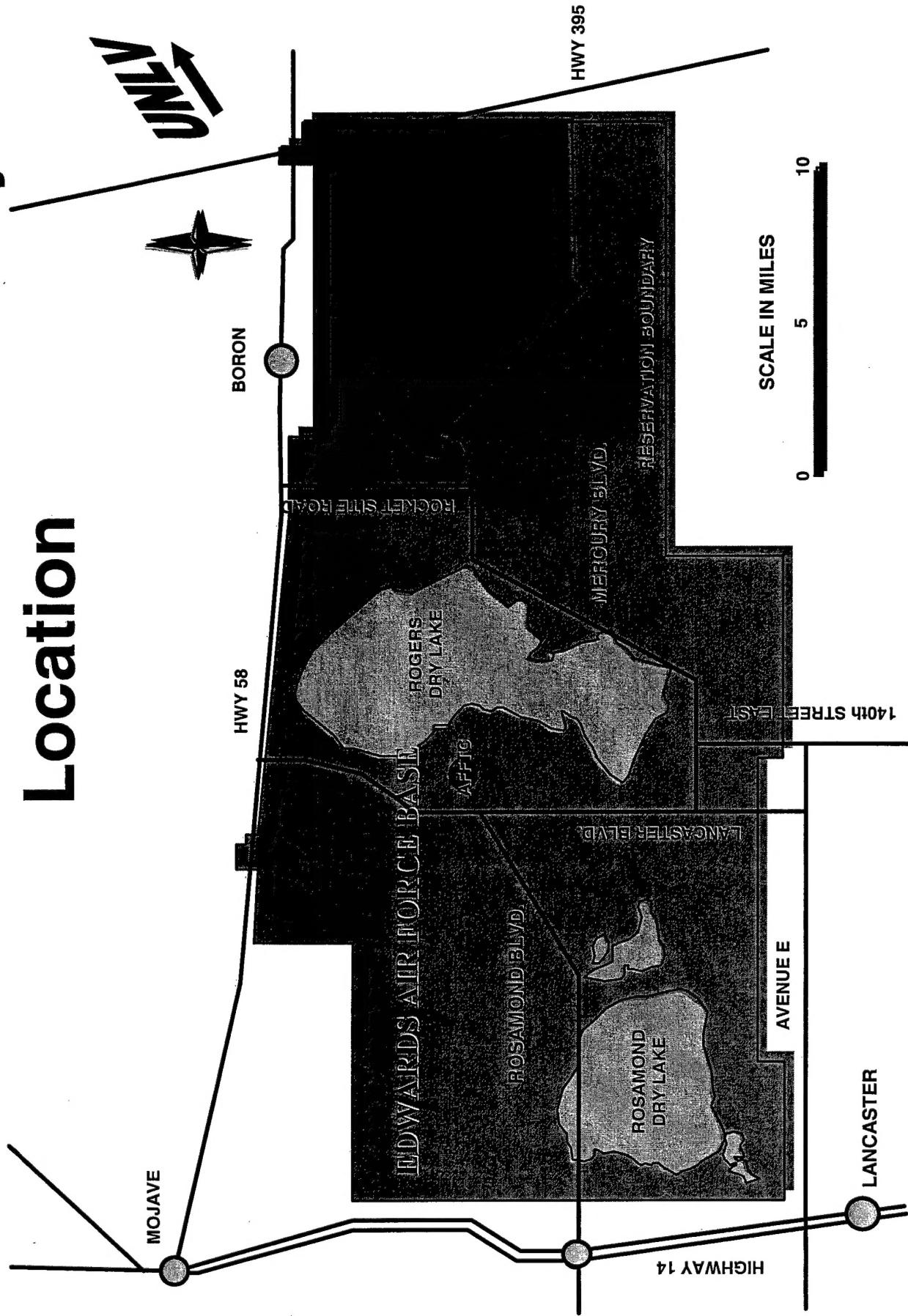
Applications R&D



Technology Transfer/Transition



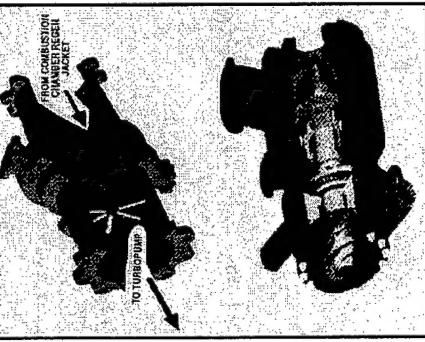
Air Force Research Laboratory Location



Air Force Research Laboratory

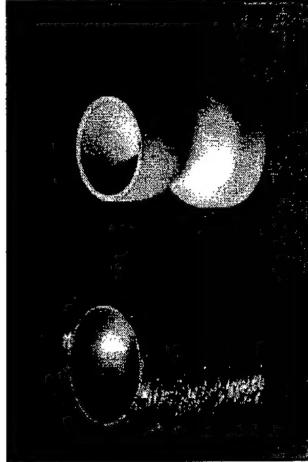
Edwards AFB / Propulsion Directorate

MISSION STATEMENT

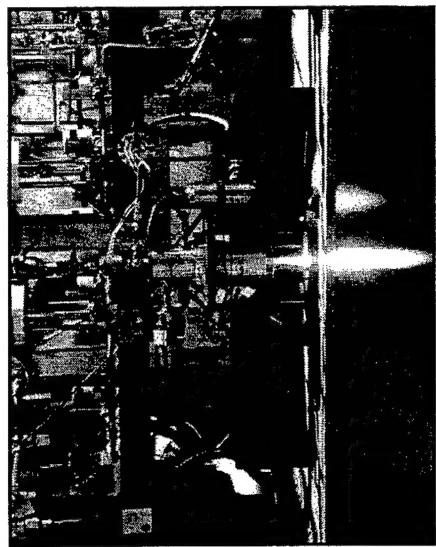


**Create and Transition
Propulsion and Power
Technology for Military
Dominance of Air and Space**

(IHPPT 2x)



CARBON / CARBON



HEDM



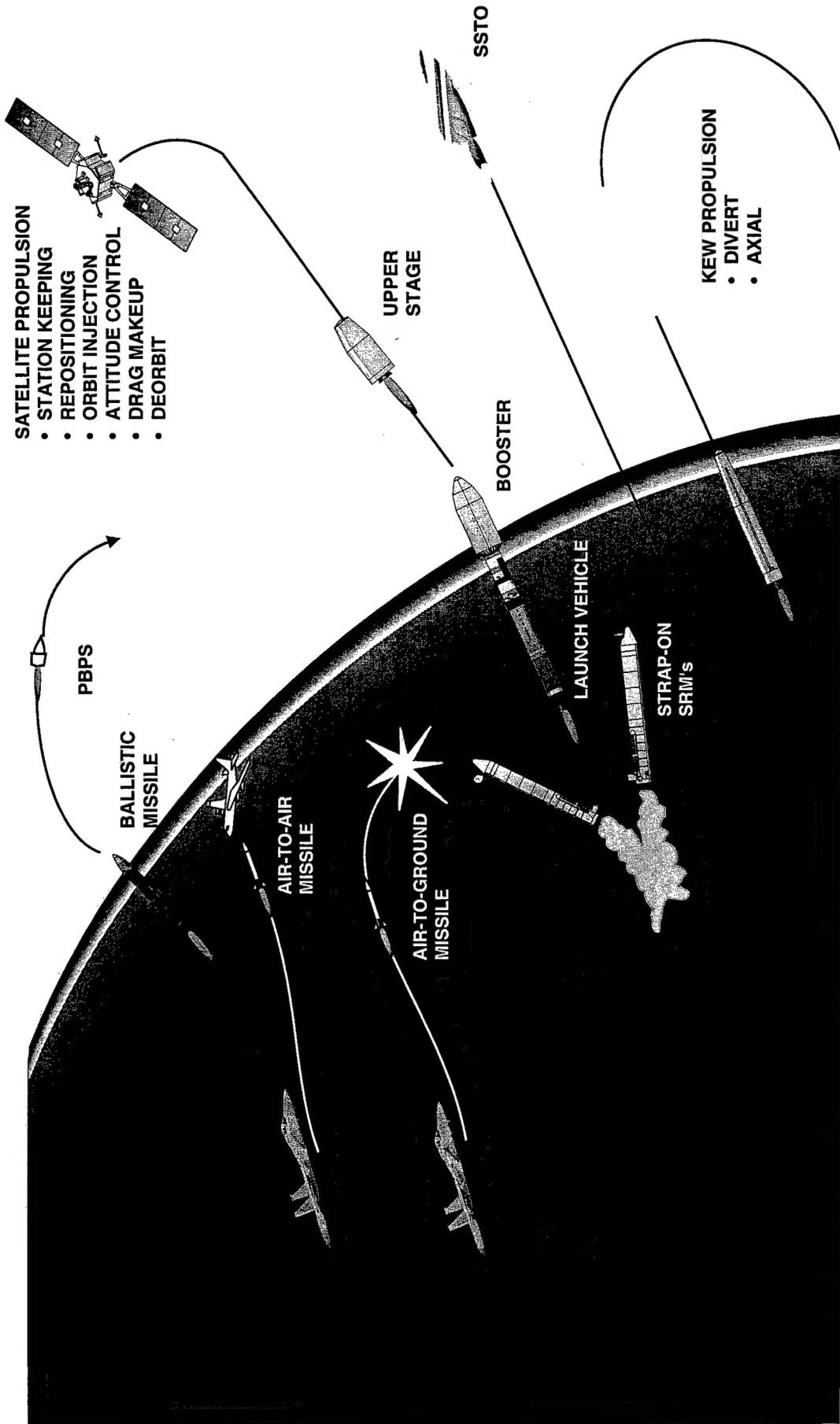
ESEX



OTV

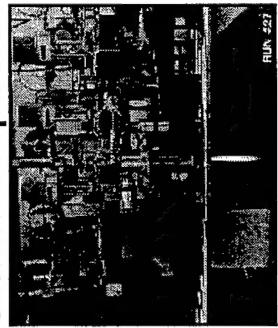
IPD

Rocket Propulsion Technology Fundamental to all Space & Missile Systems



Edwards Research Site Propulsion Directorate

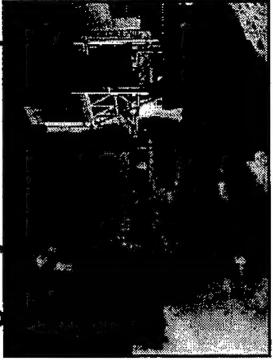
Satellite Propulsion



Experimental Systems



Large Systems Complex



Small Solid Components



TO 10,000,000 LB THRUST
FIXED OR SPUN
HORIZONTAL OR VERTICAL
ORIENTATION
ENVIRONMENTAL CONDITIONING
HIGH HAZARD

High Thrust (Solid and Liquid)



Large Solid Components



VEHICLE FLIGHT/HOVER TESTING
REDUCED SMOKE PROPULSION STUDIES
SOLAR THRUSTER EXPERIMENTS
SATELLITE g LOAD STUDIES
TETHERED LAUNCH CAPABILITY

High Hazard (Solid)

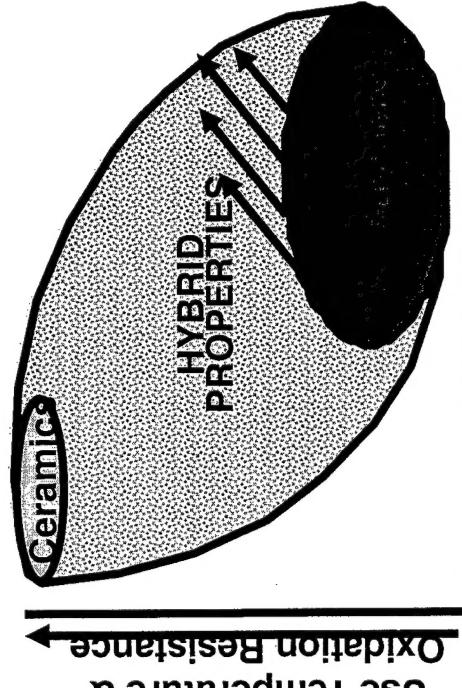


Large Liquid Components



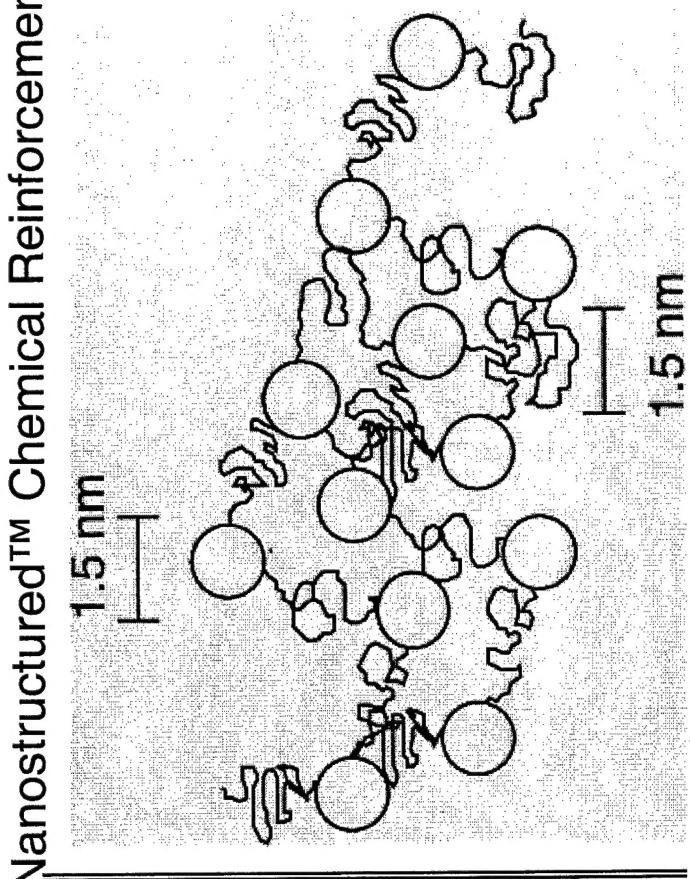
Key Aspects of POSS™ Technology

Hybrid (inorganic/organic) Composition

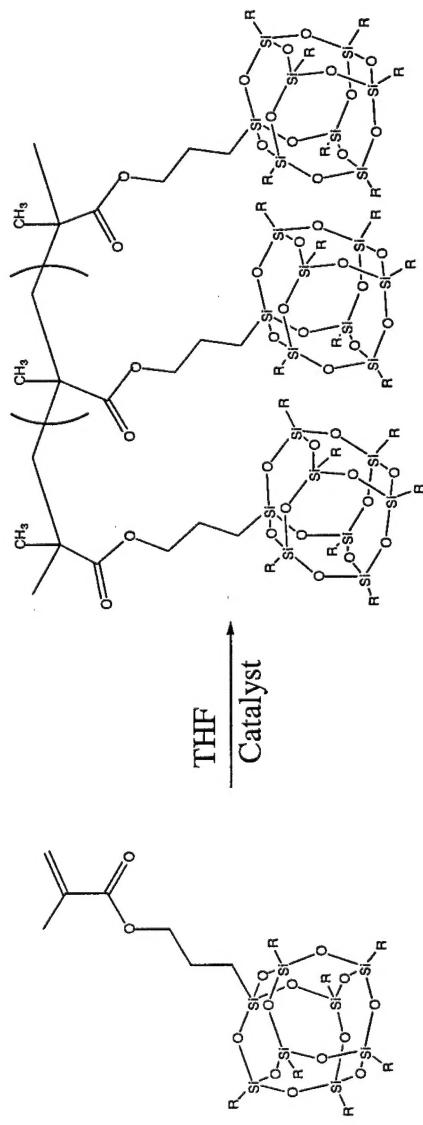


Toughness, Lightweight &
Ease of Processing

Nanostructured™ Chemical Reinforcement



POSS™ technology does not
require manufacturers to
retool or alter existing
processes.



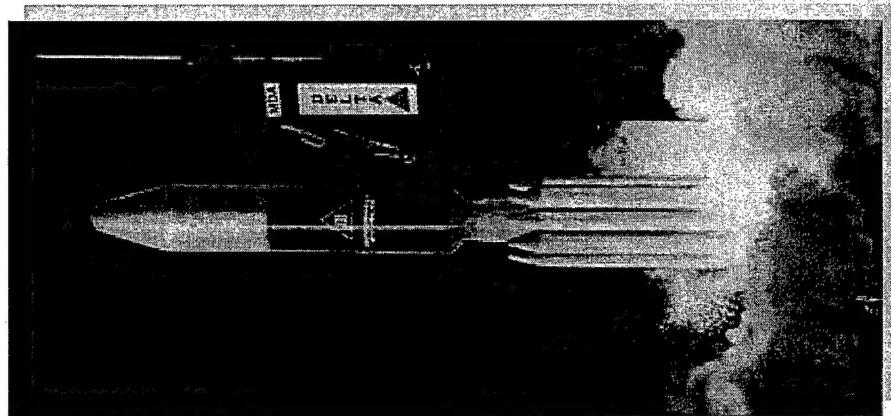
Lichtenhan et. al. *Macromolecules* 1993, 26, 2141.
Lichtenhan, Polym. Mater. Encyclopedia 1996, 10, 7768.

POSS[®] for Propulsion & Beyond

High-Performance Nanostructured Polymers

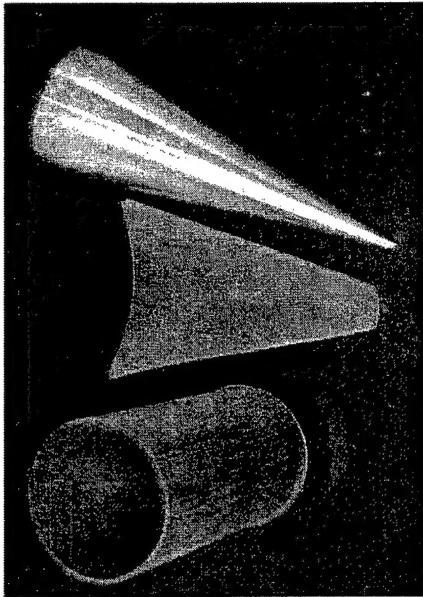
- High temperature case and motor insulation for solid rockets
- Plastic tubing and ducting for liquid rockets engines
- Space-survivable materials and coatings
- High-temperature canopies and hybrid lubricants

POSS Nanotechnology Offers Versatility!

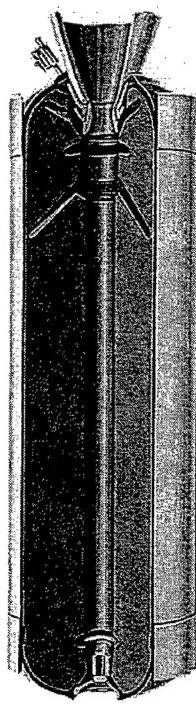


Solid Rocket Motor Insulation Program

POSS-Insulation



Case Insulation

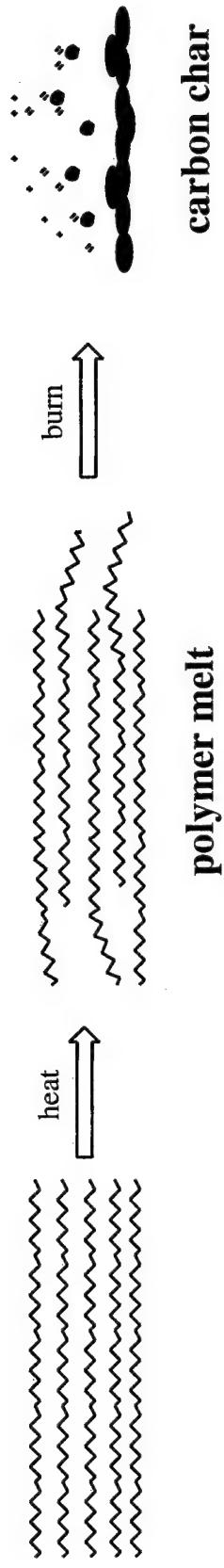


Why POSS?

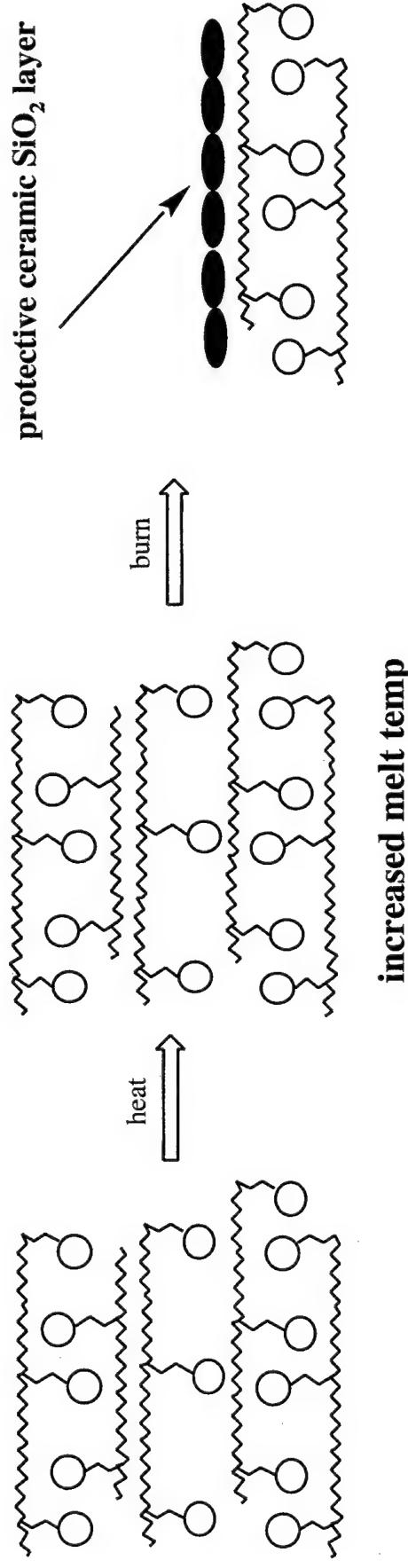
- need inorganic material with polymer flexibility
- ability to incorporate very high loadings
- processable using traditional equipment!!
- maintain mechanical property range
- physical cross-linker for TPEs

POSS for Ablative Materials

Traditional Polymer



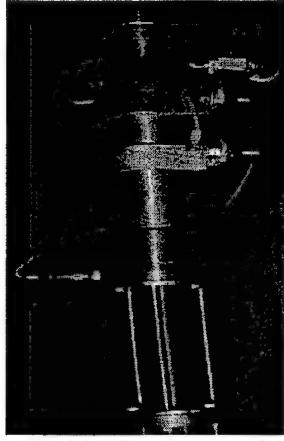
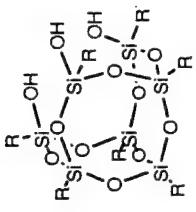
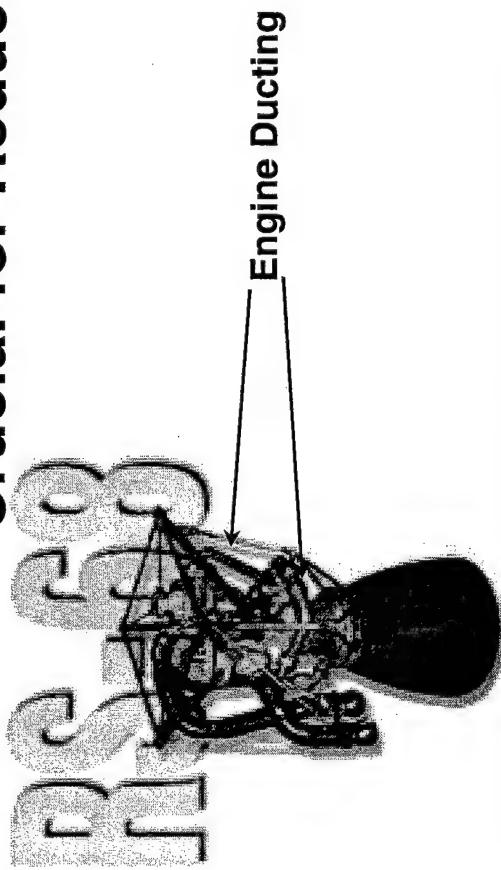
POSS Polymer



The Silicon to Oxygen ratio of 1:1.5 may be the key!!!

Liquid Rocket Engines

Crucial for Reducing Weight and Cost



Polymer Tube/Case Hot Gas Burst Tester

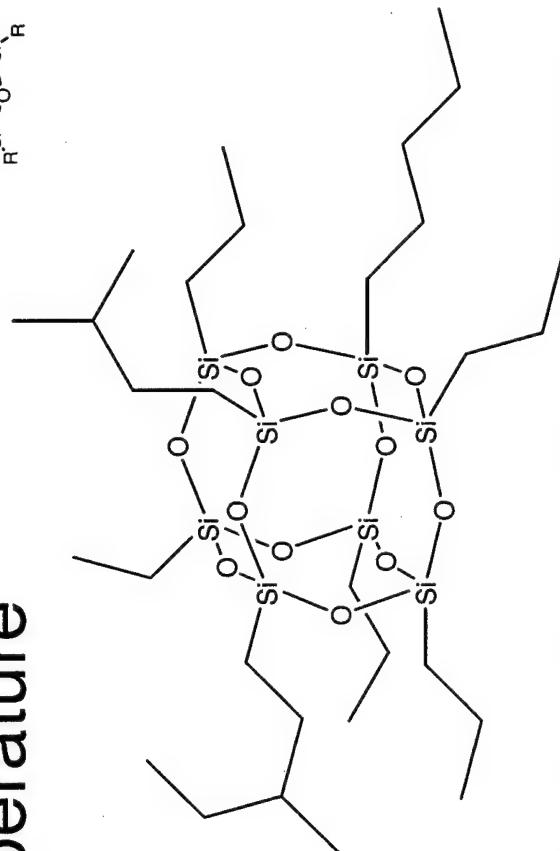
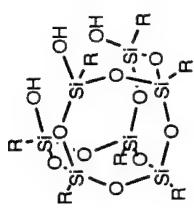
Why POSS?

- need to improve thermal & mechanical properties of SOTA polymers (PC, PPS, TPI, PEEK, PEI)
- Cornucopia of monomers for copolymerization reactions
- NO CTE mismatch (cryogenic capability)
- Potential for extrusion!

POSS Materials for Aerospace

High Temperature

Hybrid Lubricant Applications



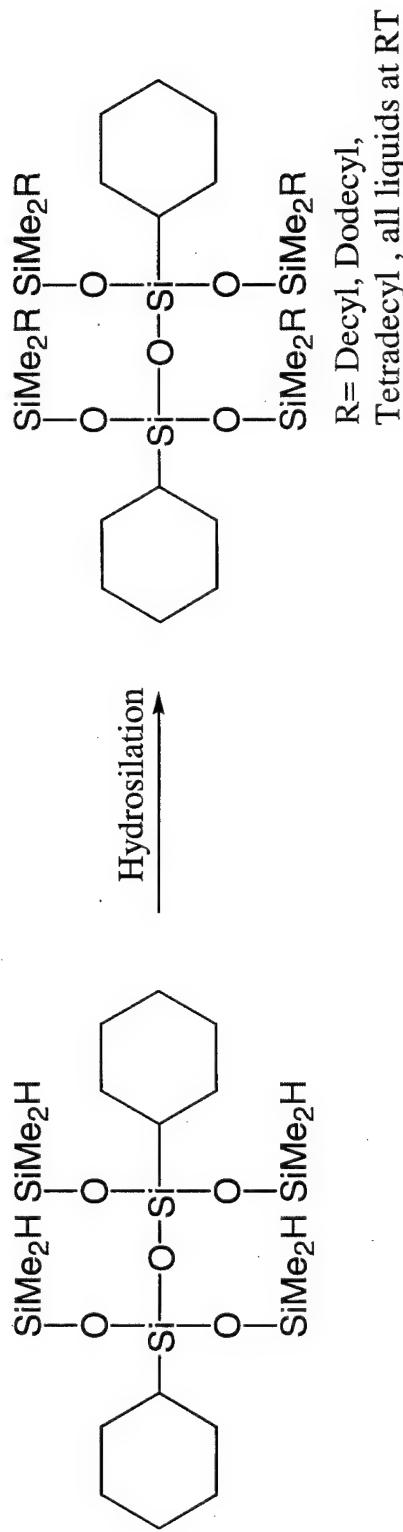
Why POSS?

-POSS based lubricants $T_{dec} = 590^{\circ}\text{F}$

-Cornucopia of monomers for compatibility and viscosity control

Generation III Lubes

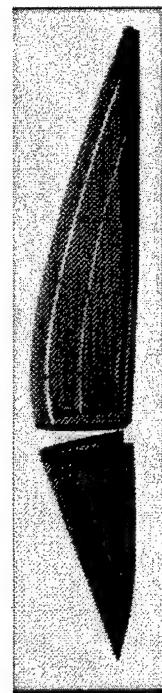
CyT₂ Class



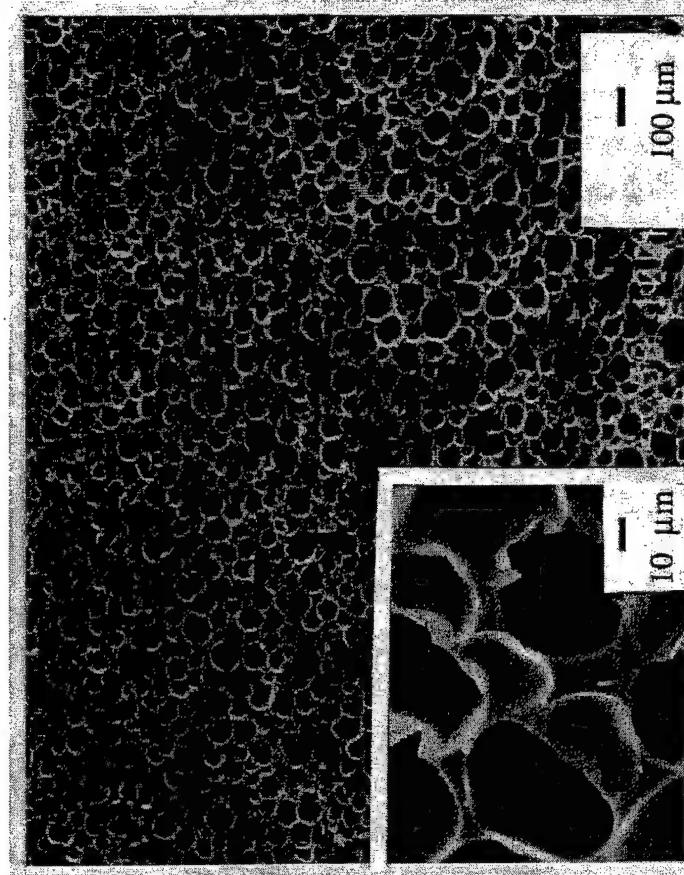
When R=Decyl the viscosity at -40 °F is 4000 cP
When R=Dodecyl, the freezing point is 10 °F
Chemical and Physical Blending Studies Show that POSS follows the Rule of Mixtures
Joint Patent with Hybrid Plastics filed this year

Dual Use S&T: WMR

Jet Canopies



WMR's Current High Performance Foam



POSS-based Transparent Materials

- Mach 2x speeds limited for plastic canopy (need increased HDT)
- Target Engagement Times can be reduced by increasing flight speed

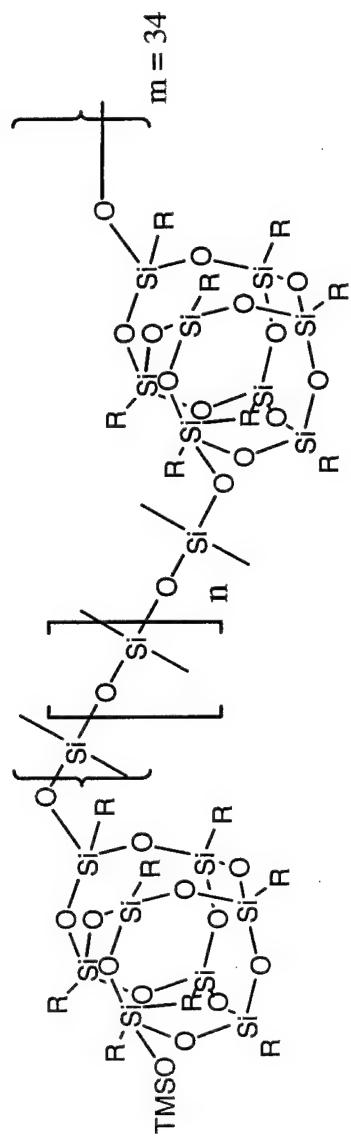
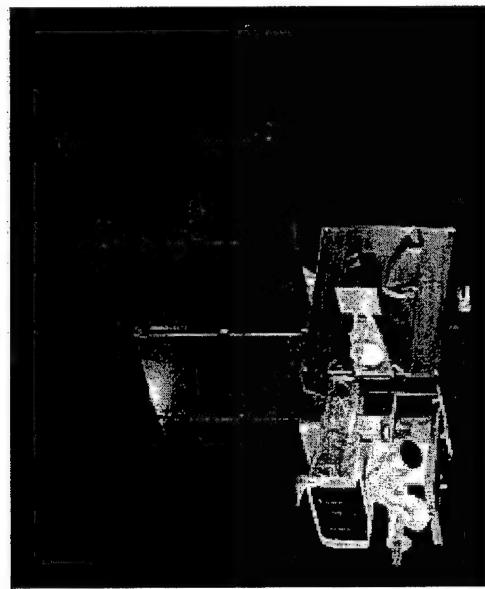
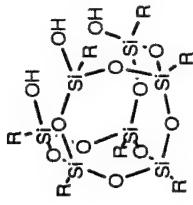
Why POSS?

POSS-PMMA increases use temp. up to 150 °C
POSS can be optically transparent!!
POSS-PMMA readily processed via foaming
Ability to make POSS-polycarbonates also

**Cell Sizes can be Tailored
From Nano To Several mm**

POSS Materials for Space

Critical for Increasing Lifetime



POSS-PDMS copolymers

Satellites & Space Systems

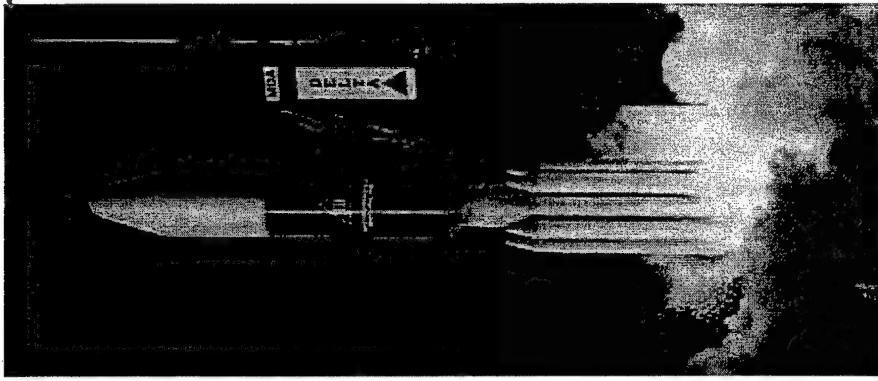
POSS Nanocomposite Payoffs

- Maximum Space Survivability
 - LEO, AO, VUV, Impact
 - Lower Density 'Filler'
 - High Modulus
 - Resins for all Structural Applications
- Simulated 3 mo. AO/VUV Exposure
 - 9-20x greater AO resistance than current state of art
 - Even better AO/VUV resistance
 - Current NASA, Aerospace Corp., and University collaborations

Where Are We Now?

Research:

New Monomers & Feedstocks (>180) - simplicity
Control & Prediction of Property Enhancements



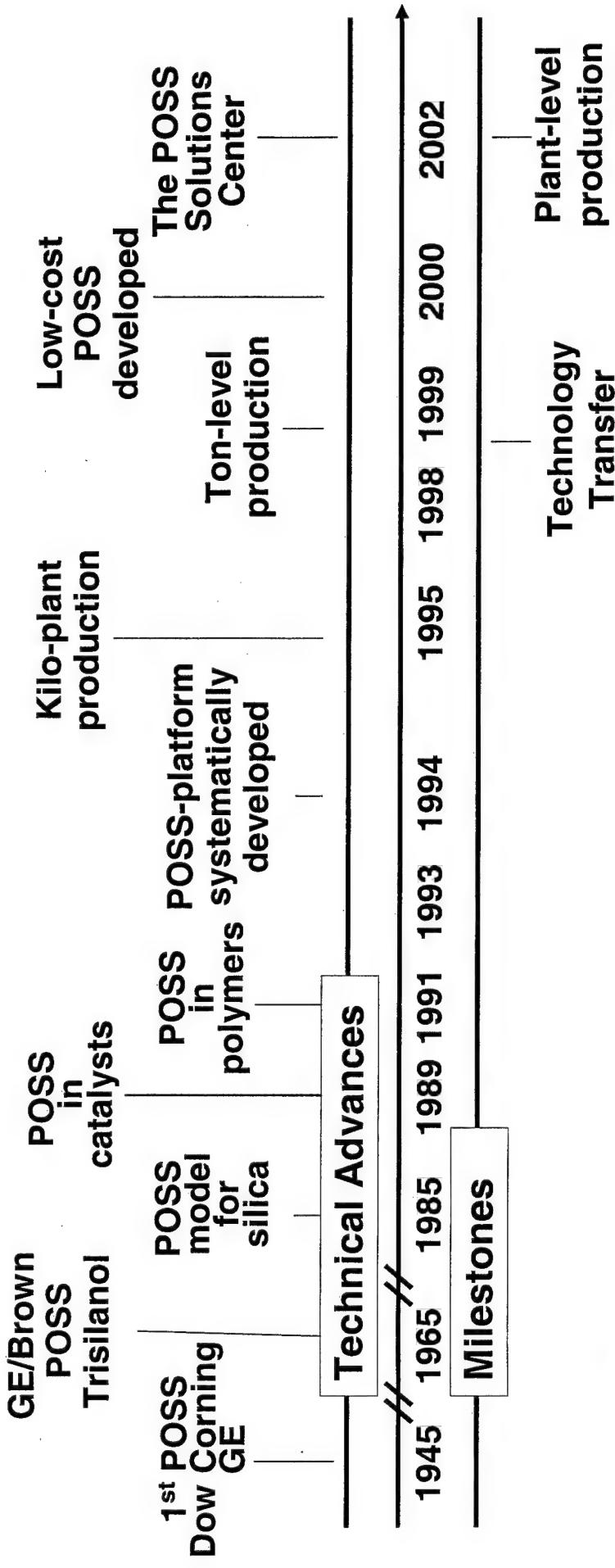
Production:

Multi-Ton Production Capability!!!
10-100x Reduction in Cost (monomer dependent)!!!

Application:

Critical & High-Risk Paths for Air Force Applications
(Insulation, Ducting, Lubricants, Space Materials)
Incorporation and R&D Testing by Numerous Companies

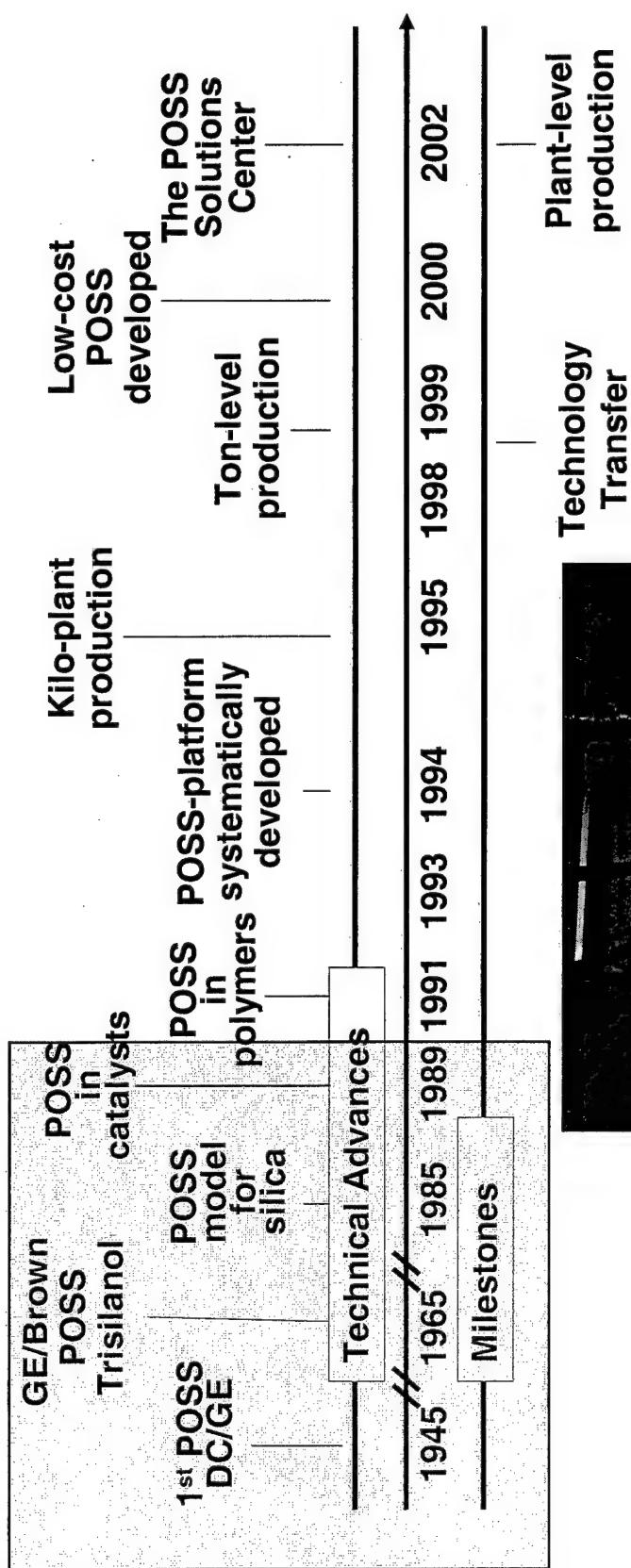
POSS™-Technology Timeline



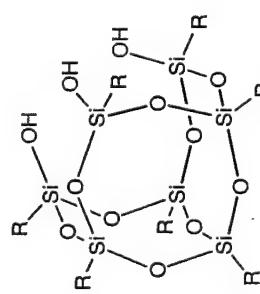
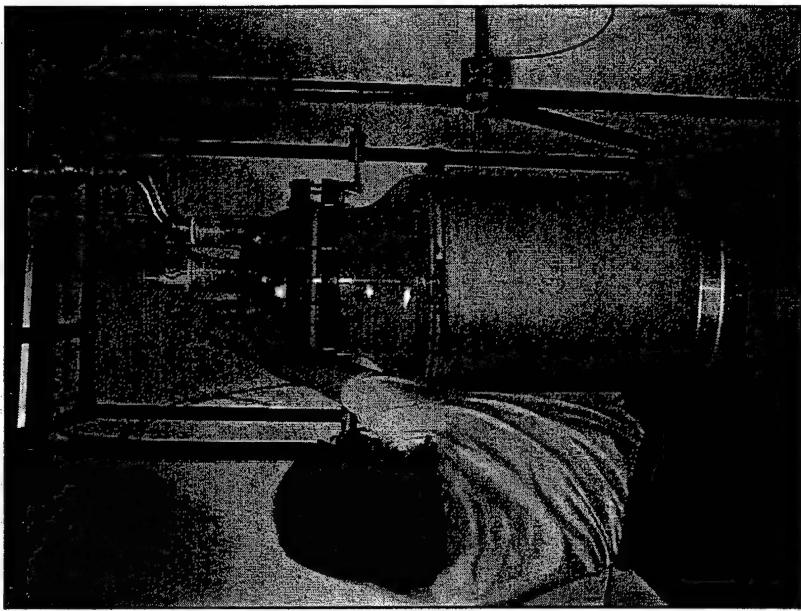
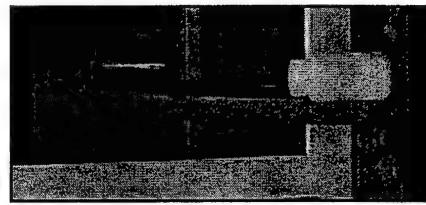
UCI Chemistry Polymers

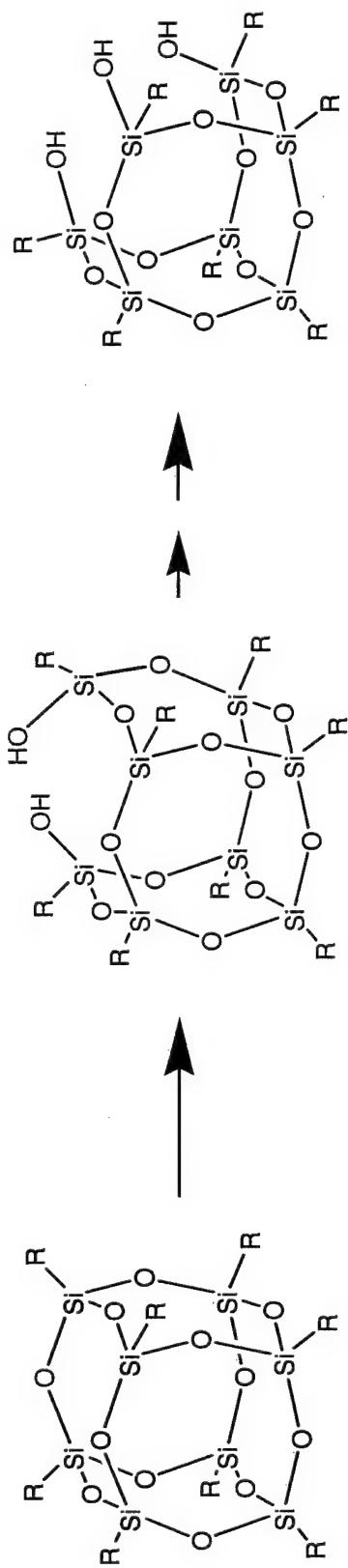
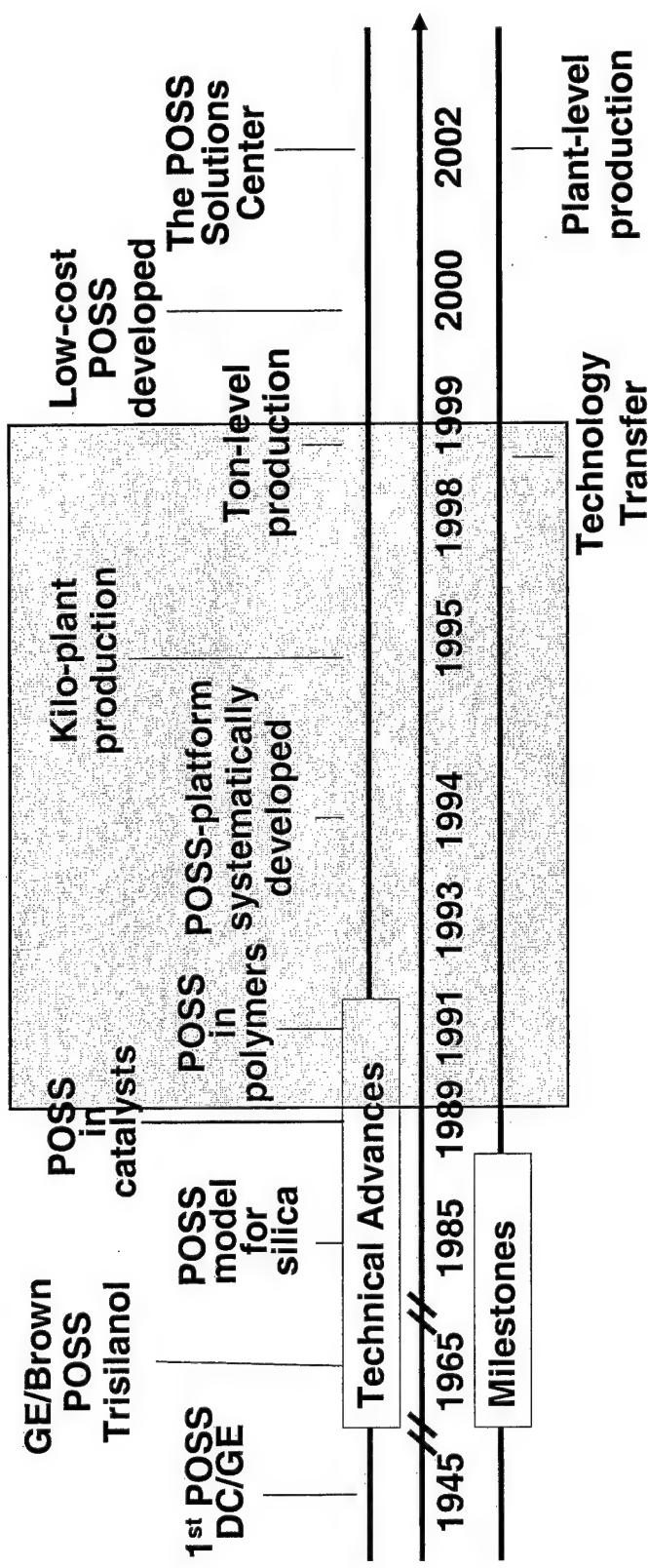
Commercial Solutions

UCI Air Force Hybrid Plastics

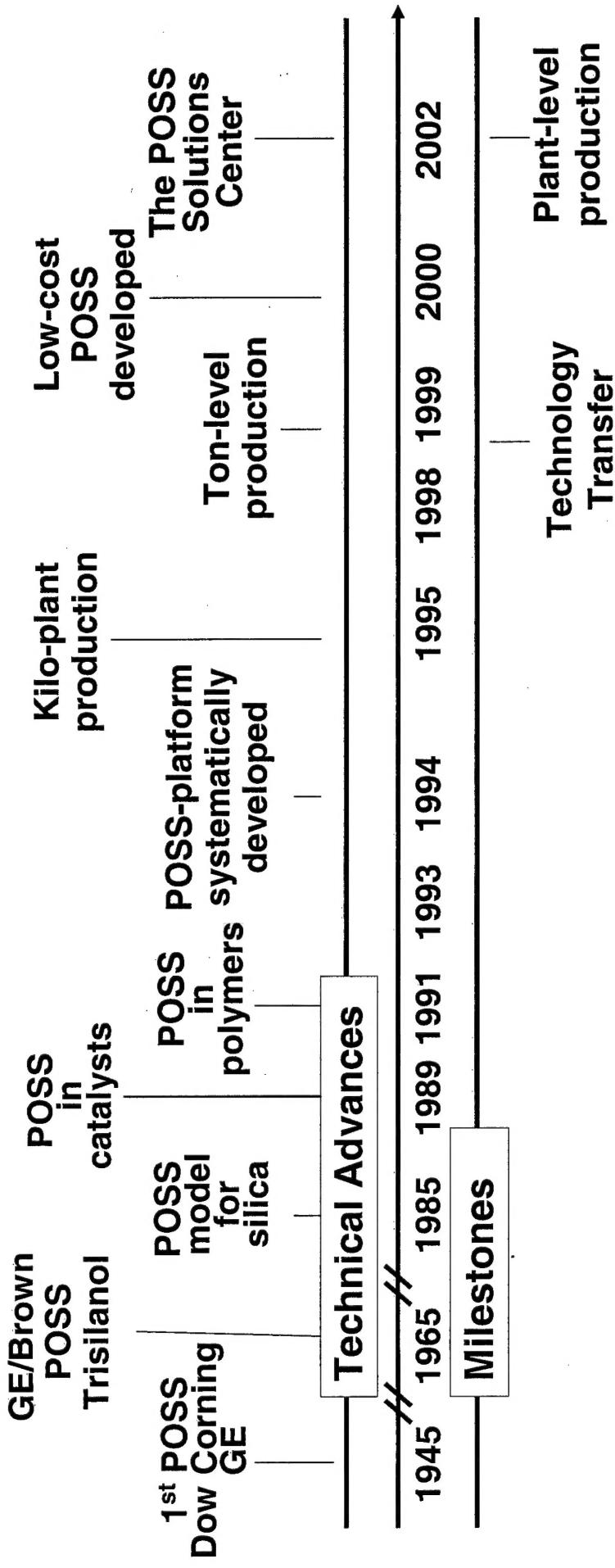


Reverse Scale-up?





POSS™-Technology Timeline



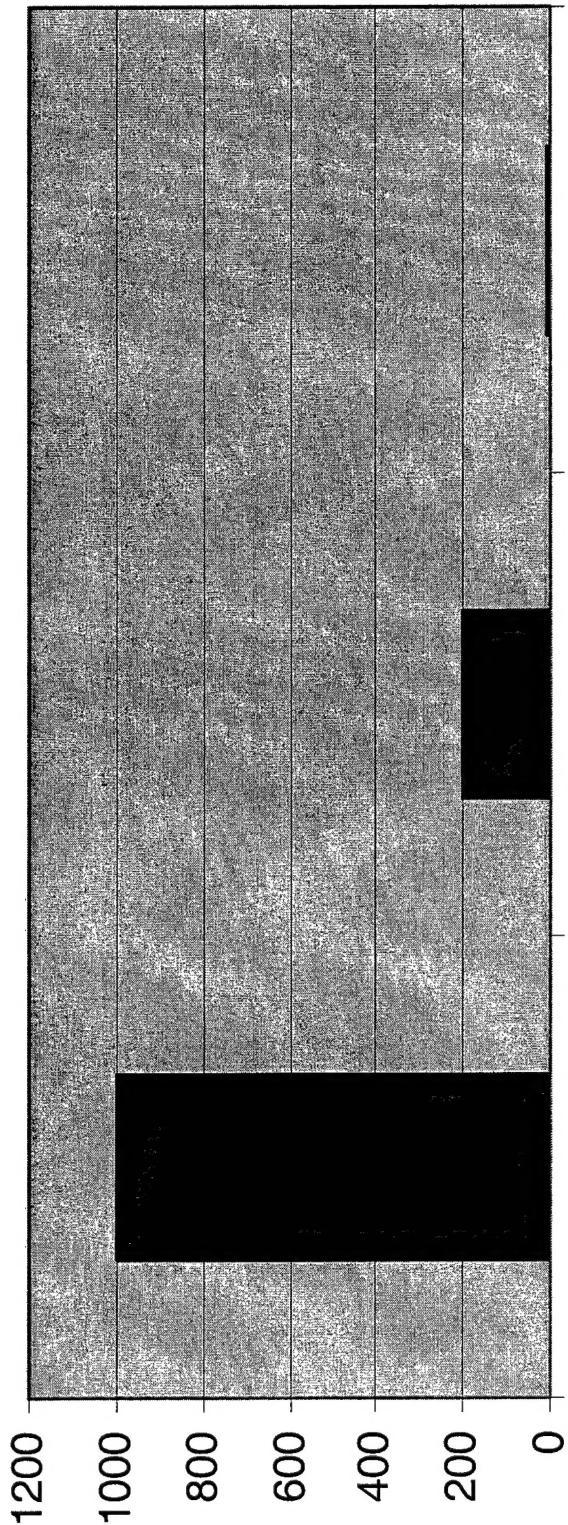
UCI Air Force Hybrid Plastics

Chemistry Polymers

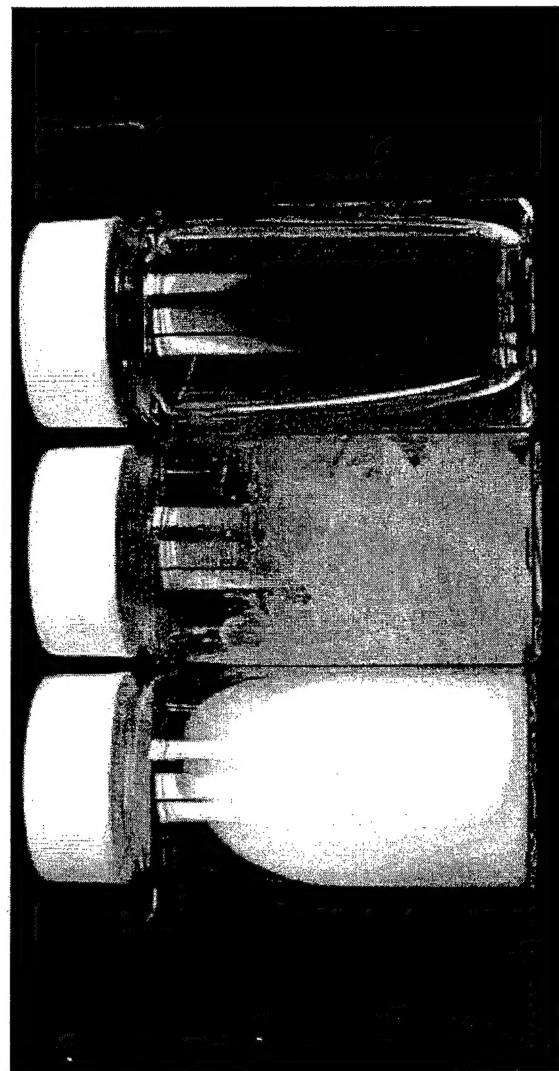
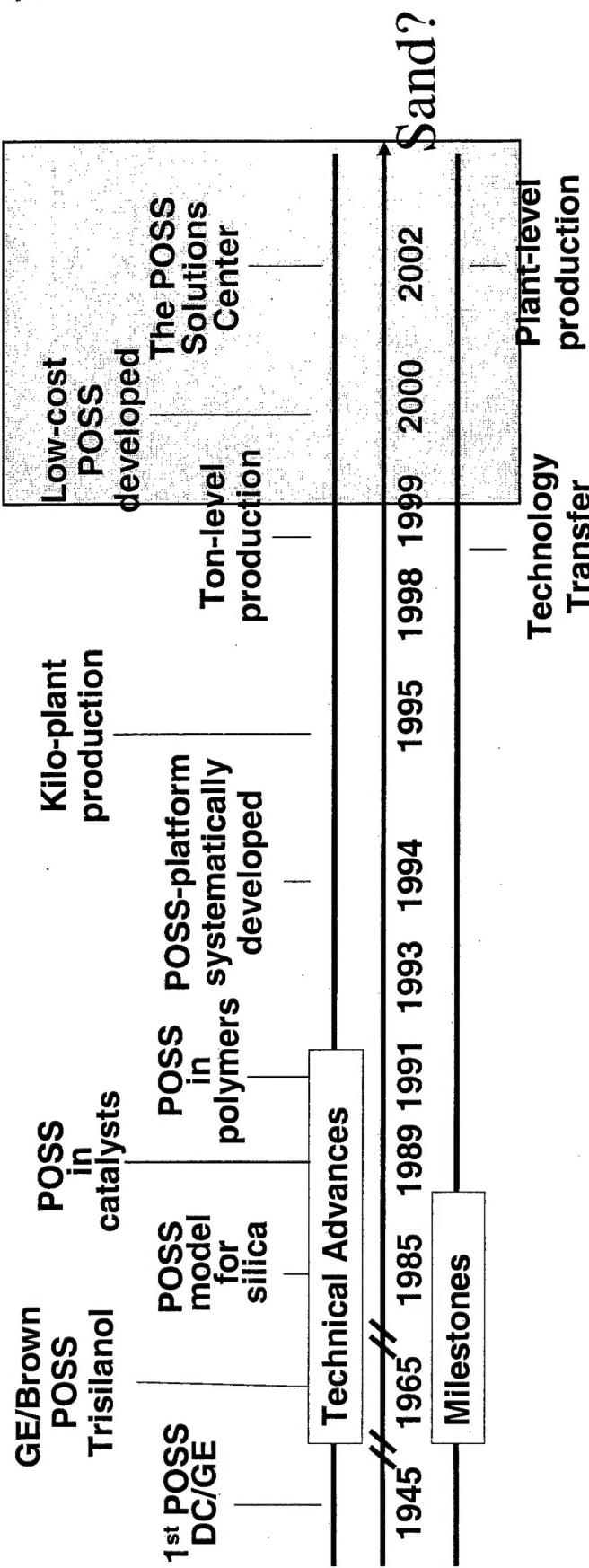
Commercial Solutions

ATP Funded Cost Reduction

Sales Price of POSS in \$ per Pound



Hybrid
Plastics[®]



Crystalline Solids Waxes

Wide melting range 24°C to 400°C+

Liquids & Oils Waxes

Wide viscosity range 40cSt. to 400cSt

Summary

The Air Force is heavily invested in POSS Applications
Research and Development

Currently one application is being ‘flight-tested’ for a
technology transition

New applications are being investigated (e.g., batteries,
capacitors, radomes)

The technology transfer to Hybrid Plastics IS a success
story with significant volume increase and price reduction

POSS Nanotechnology Offers Versatility!!